

# Spatial–Typological Structure and Organization of the Winter and Early Spring Bird Assemblages on the Northern Macroslope of the Kyrgyz Ridge (Tien Shan)

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**Abstract**—The hierarchical classification was drafted and the spatial–typological structure of the winter and pre-spring bird assemblages is described for the northern macroslope of the Kyrgyz Ridge. The descriptiveness of the classification and structural representations, as well as an evaluation of the variability of communities in relation to environmental factors, are determined using a linear approximation of quality, structure, and organization of bird assemblages in these periods. In general, the heterogeneity of bird communities on the northern slope of Kyrgyz Ridge in winter and early spring periods is associated with the variability in heat and humidity, as well as the presence of built-up areas and single-crop agriculture. In winter, changes in avifauna are more gradual than in the early spring period.

**Keywords:** bird assemblages, territorial heterogeneity, environmental factors, assessment of linkages, structure, classification

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## INTRODUCTION

This paper is the first in a series of works on analyzing the spatial–typological organization of bird communities on the Kyrgyz Ridge. This work is aimed at analyzing the variability of ornithocomplexes (i.e., species groups dominating in their abundance and biomass, assemblages densities and total biomass, species richness (general and background), and faunistic composition (with account of abundance)), as well as determining the environmental factors correlating with the heterogeneity of the bird communities.

## MATERIALS AND METHODS

Year-round bird censuses from June 16, 1991, to June 15, 1992, were conducted in 22 main habitats. Censuses were conducted on routes in 18 habitats and on observable plots (small settlements and sheep yards) in 4 habitats. The total length of routes was 665 in winter and 180 km in early spring. Censuses were conducted without limitation of transect width and with the subsequent recalculation of data by mean-group ranges of detection. A 5-km route was passed in each habitat with 2-week repetition (Ravkin and Livanov, 2008).

According to the results of censuses using the method of orderly classification separately for each

level of elevations (highlands, midlands, and foothills), seasonal aspects of bird communities were estimated (Davranov, 2011). Their boundaries do not always coincide. Therefore, the winter aspect of bird communities in the highlands starts in early October and ends in late February, in the middle levels it lasts from mid-November to the end of February, and in the foothills it lasts from mid-November to mid-February. Thus, the aspect of winter in the highlands takes 5 months, in the middle levels 3.5 months, and in the foothills 3 months. In the highlands, winter aspect begins six weeks earlier than in the foothills and the middle belt of mountains. It ends in the highlands and at middle levels at the same time and in the foothills two weeks earlier. Early spring aspect in the highlands and at middle levels was observed in March, and in the foothills it had come and gone two weeks earlier. According to the data averaged by seasonal aspects, Jaccard–Naumov coefficients of similarity were calculated. Using the program of factor classification, features of the environment that correlate with heterogeneity of the bird communities were determined (Trofimov, 1976; Trofimov and Ravkin, 1980) and the classification was obtained, which was used for building a similarity graph.

Gradations of the main structure-forming environmental factors and their indivisible combinations (nat-

ural regimes) were determined according to the results of cluster analysis.

For example, upon splitting of a set of samples, five clusters were identified. An analysis of the cluster composition indicated that the first of them included variants of bird communities in forests, the second in mosaic habitats, the third in open terrestrial habitats, the fourth in water bodies, and the fifth in settlements. In this case we can consider that the heterogeneity of ornithocomplexes was correlated with three environmental factors—forest coverage with the following gradations: high, mean, and low levels of forest trees; water (water bodies—land); and the degree of building up (present—absent). Rescaling these classes may reveal less important factors, e.g., moistening, when the communities of open habitats are subdivided into communities groups of swamps and dry valleys. Environmental factors, whose differences coincide with the heterogeneity of communities, may be considered structure-forming. As a rule, they are complex. For example, forest coverage is determined by zonal heat maintenance, swamping, flooding and anthropogenic influence (cutting of trees and ploughing up). Therefore, this is basically an indivisible combination of relatively simple factors. Their sets are called natural—anthropogenic regimes. In such cases, another combination was also used: a regime marker of the character of environment.

In the case of afforestation, this is the number of trunks per square unit. All estimations of environment have a qualitative character. They are subject to expert estimation (many, medium, little, or by the presence—absence principle). For an estimation of the binding strength of environmental factors and heterogeneity of ornithocomplexes, we used the method of linear qualitative approximation, a qualitative analogue of the regression model. Methodology and methods of classifying communities and determining their structure and organization were described earlier (Ravkin, 1978; Ravkin and Livanov, 2008), so they are not given here.

The list of habitats studied and their elevations are given in classifications of winter and early spring assemblages of birds.

Bird species names are indicated according to Ivanov (1978), except for the black-throated thrush, gray-headed goldfinch, and Masked wagtail which, following Stepanyan (2003), were considered separate species. Their names are given according to the last review.

## RESULTS

### *Winter Aspect of Bird Assemblages*

The classification of winter communities of birds is represented by three systems (supertypes) determined by three vertical rows according to the building up and moistening (non-built-on and built-on land and rivers). The first row has two deviations related to the afforestation and ploughing up, the second has one

deviation, and the third is reduced to two subtypes. Repeated aggregation by winter communities of birds allowed the combination of part of variants somewhat otherwise than by rows. Such a combination by non-built-on land is close to elevation levels. Only highland should be divided into two levels, upper and lower (alpine meadows and everything else), whereas foothills should be subdivided into forest steppe and semi-desert. The division of bird communities in settlements coincides exactly with elevation levels, but within the supertype of the built-on lands. The classification of winter communities of birds is given below.

### *Supertype of Assemblages of Non-Built-On Lands*

#### *Communities Types*

1. Highland alpine meadow (leaders by abundance, %, are *Eremophila alpestris* Linnaeus, 1758: 46, *Pyrrhocorax pyrrhocorax* Linnaeus, 1758: 20, *Tetraogallus himalayensis*, G.R. Gray, 1843 and *Montifringilla nivalis*, Linnaeus, 1766: 11 each, *Carduelis caniceps* Vigors, 1831: 6; leaders by biomass, %, are *T. himalayensis*: 72, *P. pyrrhocorax*: 16, *E. alpestris* and *Gypaetus barbatus* Linnaeus, 1758: 5 each, *M. nivalis*: 1; communities density, individuals per 1 km<sup>2</sup> was 38; biomass, kg/km<sup>2</sup>, was 13; number of species found was 13, including 6 common species; part of representatives of dominant types of the fauna, by abundance, %, was 46 for the Arctic type, 24 for the Tibetan type, and 23 for the Mongolian type);

2. Highland subalpine meadow (subalpine meadows, elfin junipers, rocks and taluses; *Prunella fulvescens* Severtzov, 1873: 17, *E. alpestris*: 13, *P. pyrrhocorax*: 11, *M. nivalis*: 10, *Alectoris chukar* J.E. Gray, 1830: 6/*A. chukar*: 25, *P. pyrrhocorax*: 24, *Columba rupestris* Pallas, 1811: 8, *Graculus graculus* Linnaeus, 1766: 7, *Pica pica* Linnaeus, 1758: 6; 247/30; 38/19; 35 of the Mongolian type of fauna, 28 of the Tibetan fauna, and 13 of the Arctic fauna).

#### *Subtypes of Assemblages*

2.1. Subalpine meadow (subalpine meadows; *E. alpestris*: 24, *M. nivalis*: 19, *P. pyrrhocorax*: 16, *P. fulvescens*: 8, *Leucosticte brandti* Bonaparte, 1850: 7/*P. pyrrhocorax*: 33, *A. chukar*: 25, *C. rupestris* and *E. alpestris*: 7 each, *G. graculus*: 6; 389/49; 28/18; 30 of the Tibetan and the Mongolian types each, 24 of the Arctic type);

2.2. Rocks and elfin woods (rocks, taluses and elfin juniper; *P. fulvescens*: 27, *Carpodacus rhodochlamys* J.F. Brandt, 1843: 11, *Mycerobas carnipes* Hodgson, 1836: 9, *Turdus atrogularis* Jarocki, 1819: 8, *P. pyrrhocorax*: 6/*A. chukar*: 25, *P. pyrrhocorax*: 15, *G. graculus*: 10, *C. rupestris*: 9, *P. pica*: 7; 175/20; 30/17; 40 of the Mongolian type, 26 of the Tibetan type, and 10 of the Siberian type).

3. Middle-mountainous forest steppe type of communities (*Serinus pusillus* Pallas, 1811: 24, *T. atrogularis*: 20, *Parus rufonuchalis* Blyth, 1849: 10, *C. caniceps*: 7, *Leptopoeile sophiae* Severtzov, 1873: 5/*T. atrogularis*: 25, *A. chukar*: 15, *Corvus corone* Linnaeus, 1758: 12, *P. pica*: 10, *G. graculus*: 7; 573/39; 58/29; 26 of the European and Mediterranean faunistic types each, 20 of the Siberian type, and 16 of the Chinese type).

#### Subtypes of Assemblages

3.1. Forest (fir forests; *P. rufonuchalis*: 40, *Parus ater* Linnaeus, 1758: 12, *L. sophiae*: 7, *P. pica*: 6 and *T. atrogularis*: 5/*C. corone*: 32, *P. pica*: 25, *P. pyrrhonorax*: 9, *T. atrogularis*: 8, *P. rufonuchalis*: 7; 406/23; 25/20; 47 of the Chinese faunistic type and 36 of the European type);

3.2. Forest—meadow and steppe (juniper forests, bushes with rocks, and meadow—steppe; *S. pusillus*: 30, *T. atrogularis*: 23, *C. caniceps*: 8, *L. sophiae*: 5, *Fringilla coelebs* Linnaeus, 1758: 4/*T. atrogularis*: 28, *A. chukar*: 18, *C. corone* and *G. graculus*: 8 each, *P. pica*: 7; 629/45; 54/27; 31 of the Mediterranean faunistic type, 24 of the European type, and 23 of the Siberian type).

#### Classes of Assemblages

3.2.1. Forest—bushes (juniper forests and bushes; *T. atrogularis*: 30, *S. pusillus*: 22, *C. caniceps* and *L. sophiae*: 6 each, *P. rufonuchalis*: 5/*T. atrogularis*: 36, *C. corone* and *G. graculus*: 11 each, *P. pica*: 9, *Phasianus colchicus* Linnaeus, 1758: 6; 668/49; 49/31; 31 of the Siberian faunistic type, 23 of the European type, 23 of the Mediterranean type, and 11 of the Chinese type);

3.2.2. Meadow—steppe (*S. pusillus*: 48, *C. caniceps*: 14, *A. chukar*: 8, *T. atrogularis* and *F. coelebs* 4 each/*A. chukar*: 61, *S. pusillus*: 8, *T. atrogularis*: 6, *C. caniceps*: 4, *Ph. colchicus*: 3; 549/36; 34/20; 49 of the Mediterranean type, 24 of the European type, and 10 of the Mongolian type).

4. Foothill forest-steppe type (floodplain forests, gardens, and steppes; *Passer montanus* Linnaeus, 1758: 26, *C. caniceps*: 23, *Emberiza citronella* Linnaeus, 1758: 21, *Acridotheres tristis* Linnaeus, 1766 and *P. pica*: 4 each/*Ph. colchicus*: 28, *P. pica*: 11, *Columba livia* J.F. Gmelin, 1789: 10, *E. citronella*: 8, *P. montanus* 7; 422/34; 43/23; 55 of the European faunistic type and 26 transpalearcts).

#### Subtypes of Assemblages

4.1. Garden—steppe (foothill steppes and gardens; *T. atrogularis*: 30, *S. pusillus*: 22, *C. caniceps*: 6, *L. sophiae*: 5, *P. rufonuchalis*: 4/*T. atrogularis*: 36, *C. corone* and *G. graculus*: 11 each, *P. pica*: 9; 668/49; 49/31; 31 of Siberian faunistic type, 23 of European

type, 23 of Mediterranean type, and 11 of Chinese type);

4.2. Floodplain—forest (*S. pusillus*: 48, *C. caniceps*: 13, *A. chukar*: 8, *T. atrogularis* and *F. coelebs* 4 each/*A. chukar*: 62, *S. pusillus*: 8, *T. atrogularis*: 6, *C. caniceps*: 4, *Ph. colchicus*: 3; 549/36; 34/20; 49 of the Mediterranean faunistic type, 25 of the European type, and 10 of the Mongolian type).

5. Foothill semidesert and field type communities (*Corvus cornix* Linnaeus, 1758: 26, *Corvus frugilegus* Linnaeus, 1758: 11, *C. caniceps*: 10, *E. citronella*: 9, *Vannellus vannellus* Linnaeus, 1758: 8/*C. cornix*: 56, *C. frugilegus*: 18, *C. corone* and *V. vannellus*: 7 each, *C. livia*: 6; 41/10; 19/12; 63 of the European faunistic type, 18 transpalearcts and 10 of the Mediterranean type).

#### Subtypes of Assemblages

5.1. Semidesert (*C. cornix*: 60, *E. alpestris* and *Alauda arvensis*: 16 and 7, *C. corone*: 6, *Galerida cristata*: 5/*C. cornix* and *C. corone*: 84 and 11, *P. pica*: 3, *E. alpestris* and *Alauda arvensis*: 2 and 0.6; 13/5; 8/2; 73 of the European faunistic type and 16 of the Arctic type);

5.2. Field (fields of wheat and clover<sup>1</sup>; *C. cornix*: 22, *C. frugilegus*: 12, *C. caniceps*: 11, *E. citronella*: 10, *V. vannellus*: 9/*C. cornix*: 51, *C. frugilegus*: 21, *V. vannellus*: 8, *C. livia*: 7, *C. corone*: 6; 55/12; 17/12; 62 of the European faunistic type, 20 transpalearcts, and 11 of the Mediterranean type).

#### Supertype of Bird Assemblages of Built on Land

##### Types of Assemblages

6. Highland settlements (small settlements<sup>2</sup>; *P. pica*: 45, *P. fulvescens*: 15, *C. corone*: 10, *E. alpestris*: 9, *A. tristis*: 6/*P. pica*: 49, *C. corone*: 30, *P. pyrrhonorax*: 7, *A. tristis* and *C. livia*: 6 each; 391/80; 13/13; 58 of the European and 21 of the Mongolian faunistic types);

7. Middle-mountainous settlements (small settlements; *P. fulvescens*: 29, *P. pica*: 26, *C. corone*: 20, *C. livia*: 10, *P. pyrrhonorax*: 7; 2097/402; 8/8; 35 of Mongolian faunistic type, 29 of the European type, and 19 of the Mediterranean type);

8. Foothill settlements (small settlements; *P. montanus*: 24, *P. pica*: 17, *Streptopelia decaocto* Frivaldszky, 1838: 16, *C. caniceps*: 14, *Streptopelia senegalensis* Linnaeus, 1766: 9/*C. corone*: 30, *P. pica*: 23, *Streptopelia decaocto*: 19, *C. cornix*: 8, *Streptopelia senegalensis*: 6;

<sup>1</sup> In winter and early spring periods, the composition of agricultural plants was determined by the presence of stubble remains and clover on snow-free plots.

<sup>2</sup> Settlements were divided into small (1–5 houses) and large; in addition, sheep yards without living houses were registered separately.

1385/227; 15/15; 46 of the European faunistic type and 26 transpalearcts);

9. Foothill settlements and sheep yards (large settlements and sheep yards; field *Passer domesticus* Linnaeus, 1758 and *P. montanus*: 23 and 42, *C. cornix*: 6, *C. livia*: 5, *C. frugilegus*: 4/*C. cornix*: 26, *C. frugilegus*: 18, *C. livia*: 13, *P. montanus* and *Corvus monedula* Linnaeus, 1758: 7 each; 7370/811; 19/18; 69 transpalearcts, 15 and 11 of the European and Mediterranean faunistic types).

#### *Supertype of Aquatic–Periaquatic Communities*

10. Riverine type (*Cinclus pallasii* Temminck, 1820 and *Cinclus cinclus* Linnaeus, 1758: 57 and 41, *Gallinago solitaria* Hodgson, 1831: 3/*C. pallasii*: 61, *C. cinclus*: 33, *G. solitaria*: 6; 367/26; 3/3; 57 of the Chinese faunistic type and 40 transpalearcts).

#### *Subtypes of Assemblages*

10.1. Highland–middle–mountainous (*C. pallasii*: 58, *C. cinclus*: 38, *G. solitaria* 4/*C. pallasii*: 62, *C. cinclus*: 30, *G. solitaria*: 8; 409/30; 3/3; 58 of the Chinese faunistic type and 38 transpalearcts);

10.2. Foothill–riverine (*C. pallasii* and *C. cinclus* 52 and 48 in abundance/59 and 41 in biomass; 282/19; 2/2; 52 of the Chinese faunistic type and 48 transpalearcts).

#### *Early Spring of Bird Communities Aspect*

Five types of communities were determined upon the classification of ornithocomplexes in this period (horizontal and not vertical rows as for winter communities): highland, highland–middle mountainous, middle mountainous–foothills, and rivers. The latter belongs to all elevation levels and does not form communities. In addition, four supertypes (systems) of communities may be determined: two of them are connected with pessimal conditions of the environment ((I) highland alpine–meadow and (IV) foothill semidesert–field) and two with optimal conditions ((II) middle, from the lower part of highlands to better moistened and nonploughed foothills: forests, gardens, settlements, sheep yards and steppes, and (III) rivers). The first supertype was determined by the deficiency of heath and the fourth by deficiency of moistening and the impoverishing influence of monocultural agrocenoses. In relatively optimal conditions of land, the second and third supertypes are formed, where the total abundance of birds is higher. In this situation, the bird density is especially high in settlements at the account of synanthrops. The communities of the nival belt and ornithocomplexes of plain deserts of Middle Asia are formed in extreme conditions. The nival belt was not explored in the Kyrgyz Ridge. Supertype subdivision in the classification and

on the graph was not shown. Classification of early spring bird communities is given below.

1. Highland alpine–meadow type of communities (leaders by abundance, %, are *E. alpestris*: 37, *P. pyrrhacorax*: 34, *T. himalayensis*: 29/leaders by biomass, %, are *T. himalayensis*: 86, *P. pyrrhacorax*: 12, *E. alpestris*: 2; population/all of them are common; proportions of members of dominant types of the fauna by abundance, %, are 37 of the Arctic type, 34 of the Mongolian type, and 29 of the Tibetan type).

2. Highland–medium mountainous settlement–meadow–steppe type of communities (*P. pica*: 30, *P. pyrrhacorax*: 20, *C. rupestris* and *C. livia*: 15 and 8, *P. fulvescens*: 7; 1235/271; 30/20; 32 of the European faunistic type, 30 of the Mongolian type, 15 of the Chinese type, and 11 of the Mediterranean type).

#### *Subtypes of Assemblages*

2.1. Highland subalpine–meadow (with penetration on rocks, taluses, and in small settlements; *P. pica* and *P. pyrrhacorax*: 19 each, *M. nivalis*: 18, *L. brandti*: 17, *A. chukar*: 5/*P. pyrrhacorax*: 30, *P. pica*: 25, *A. chukar*: 15, *C. corone*: 7, *G. graculus*: 5; 425/72; 25/18; 42 of the Tibetan type, 29 of the Mongolian type and 22 of the European type);

2.2. Middle–mountainous meadow–steppe (with penetration on highland elfin junipers; *S. pusillus*: 39, *A. chukar*: 23, *Calliope pectoralis* Gould, 1837: 8, *Phoenicurus erythrogastrus* Gldenstdt, 1775: 7, *P. fulvescens*: 5/*A. chukar*: 83, *S. pusillus*: 3, *T. atrogularis*: 3, *P. pica*: 2, *C. rhodochlamys*: 1; 268/36; 17/13; 39 of the Mediterranean type, 34 of the Mongolian type, and 12 of the Tibetan type);

2.3. Middle–mountainous settlements (*P. pica*: 34, *P. pyrrhacorax*: 22, *C. rupestris* and *C. livia*: 19 and 10, *P. fulvescens*: 8/*P. pica*: 32, *P. pyrrhacorax*: 25, *C. rupestris* and *C. livia*: 22 and 12, *C. corone*: 7; 5600/133; 8/8; 37 of the European type, 30 of the Mongolian type, 19 of the Chinese type, and 10 of the Mediterranean type).

3. Middle–mountainous settlements–forest steppe type (*P. montanus* and *P. domesticus*: 31 and 15, *G. graculus*: 6, *A. tristis* and *E. citronella*: 4 each; 2702/286; 58/45; 52 of transpalearcts, 25 of the European faunistic type, and 11 of the Mediterranean type).

#### *Subtypes of Assemblages*

3.1. Middle–mountainous forest (juniper and fir forests with penetration in bushes with rocks and taluses; *P. rufonuchalis*: 23, *T. atrogularis*: 14, *Loxia curvirostra* Linnaeus, 1758: 9, *P. ater*: 7, *L. sophiae*: 6/*T. atrogularis*: 21, *P. pica*: 13, *Perdix daurica* Pallas, 1811 and *C. corone*: 12 each, *Turdus merula* Linnaeus, 1758: 7; 477/27; 32/26; 31 of the Chinese type, 25 of the European type, 23 of the Siberian type, and 10 of the Tibetan type);

3.2. Foothill steppe (with penetration in floodplain forests, apple gardens, and small settlements of foothills; *C. caniceps*: 15, *E. citronella*: 13, *P. montanus*: 10, *P. pica*: 9, *C. corone*: 7/*C. corone*: 34, *P. pica*: 15, *A. chukar*: 8, *C. livia*: 7, *A. tristis*: 6; 1096/152; 39/29; 53 of the European type, 13 of the Mediterranean type, and 10 transpalearcts).

3.3. Foothill settlement—sheep yards (large settlements and sheep yards; *P. montanus* and *P. domesticus*: 39 and 19, *C. monedula*: 8, *C. cornix* and *Sturnus vulgaris* Linnaeus, 1758: 5 each/*C. cornix*: 25, *C. frugilegus*: 15, *C. monedula*: 14, *C. livia*: 10, *P. montanus*: 9; 9250/940; 22/22; 66 transpalearcts, 18 of the European type, and 11 of the Mediterranean type).

4. Foothill semidesert and field type of communities (*E. citronella*: 42, *A. arvensis*: 28, *C. corone* and *C. cornix*: 16 and 14/*C. corone* and *C. cornix*: 51 and 37, *E. citronella*: 6, *A. arvensis*: 5; 1/0.2; 4/0; 72 of the European faunistic type and 28 transpalearcts).

#### Subtypes of Assemblages

4.1. Semidesert (*A. arvensis*: 49, *C. corone* and *C. cornix*: 26 and 24/*C. corone* and *C. cornix*: 54 and 40, *A. arvensis*: 6; 2/0.6; 3/1; 51 of the European type and 49 transpalearcts);

4.2. wheat fields (*E. citronella*: 97, *C. corone*: 2, *C. cornix*: 1/*E. citronella*: 63, *C. corone* and *C. cornix*: 26 and 10; 2/0,07; 3/1; 100 of the European faunistic type);

4.3. clover fields (*C. corone* and *C. cornix*: 67 and 33 by abundance/72 and 28 by biomass; 0.02/0.09; 2/0; 100 of the European faunistic type).

5. Riverine type of assemblages (*C. pallasii*: 41, *C. cinclus*: 33, *Motacilla personata* Gould, 1861 and *Motacilla cinerea* Tunstall, 1771: 16 and 7, *G. solitaria*: 2/*C. pallasii*: 54, *C. cinclus*: 32, *M. personata*: 7, *G. solitaria*: 5, *M. cinerea*: 2; 451/26; 5/5; the Chinese type and the transpalearcts were 41 each).

#### Structure of Ornithocomplexes

The similarity graph of the winter communities is represented by 3 supertypes (vertical rows or systems). Their representation is different (Fig. 1). The first forms an ornithocomplex in non-built-on terrestrial habitats, the second one in built-on habitats, and the last (consisting of one type of aquatic and periaquatic communities) is not connected with other communities. There are no monotonous changes in bird communities parameters by taxa of classifications.

According to the classification and the graph, the main changes in bird communities in the early spring period are connected with the absolute values of elevations (Fig. 2). Four horizontal rows of differences may be identified there: highland, highland—middle mountainous, middle mountainous—foothills, and foothills. Differences in these rows determine heat and moisture

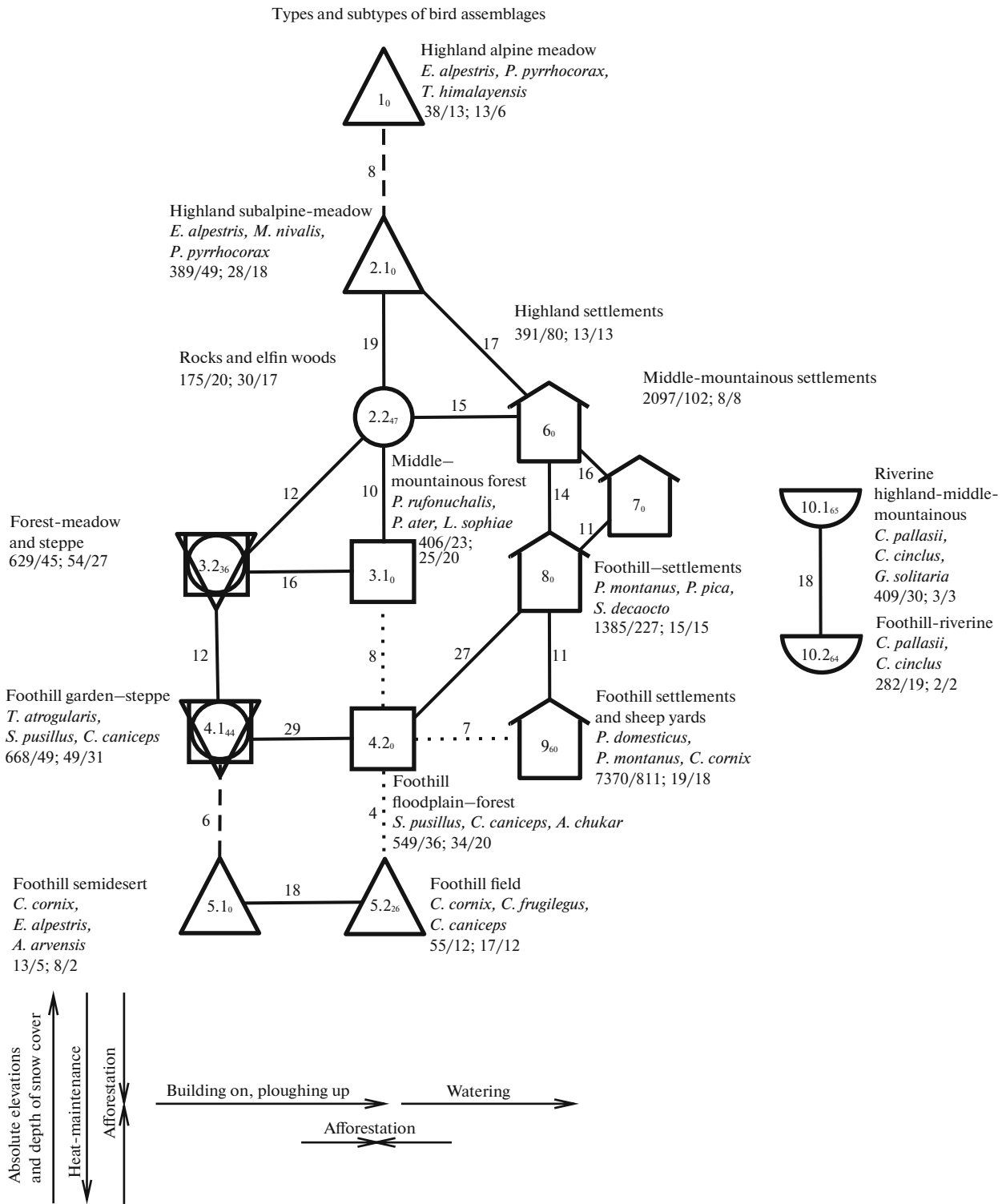
provision. Inside the rows they correlate with the extents of building on lands, their afforestation, the presence of water, extent of ploughing up, and composition of agricultural crops. Ornithocomplexes in small settlements (except for those in the middle mountain belt) fall in general types with communities of adjacent habitats. Small settlements in the middle mountain belt differ significantly from ornithocomplexes of adjacent habitats. They were determined as a separate assemblages type. Ornithocomplexes of foothill sheep yards and large settlements are similar, despite the differences in their square, because they contain similar food resources (sheep yards due to the presence of combined feeds for cattle and large settlements due to food wastes from the larger number of people).

#### Spatial—Typological Organization of Bird Assemblages

The maximum linkage of the changes in winter communities of birds is connected with watering: 45% of the dispersion of the similarity coefficients matrix. The correlation with food availability and number of human buildings is lower (table). Strengths of linkages with absolute elevations of habitats and their afforestation are almost equal. Absolute elevations influence the heterogeneity of bird communities indirectly by presence or thickness of snow cover on land surface. At a qualitative level, however, the characteristics are fully correlated with the level of elevations, so in the list of factors and regimes these correlated characters are present once under the title “absolute elevations of habitats,” because they are the first cause of many elevation—dependent factors. Other factors are weakly connected with the heterogeneity of winter communities of birds. Watering of habitats has a maximum influence on the formation of bird communities in winter and early spring. The connection with the extent of building and productivity was 2.4–5 times less. The informativeness of all factors for the winter period was 81% and for the early spring 84%; that of regimes was, correspondingly, 87 and 79%; and all regimes and factors were 93 and 92%.

#### DISCUSSION

Tsybulin (2009) distinguished six types of communities for the winter period in Altai: alpine—tundra, forest, forest—meadow—steppe, steppe, synanthropic, and lake—riverine. Ten communities types were described on the Kyrgyz Ridge for the same period, two instead of the alpine—tundra: alpine—meadow and subalpine—meadow with the penetration into elfin forests. The forest—meadow—steppe type of the Altai is represented by 2 subtypes on the Kyrgyz Ridge, namely, forest and forest—meadow—steppe. The synanthropic type identified on the Altai is subdivided on the Kyrgyz Ridge into four types separately by elevation levels. The forest type is nominally similar in two regions, whereas the semidesert one was identified



**Fig. 1.** Spatial-typological structure of winter bird communities on the Kyrgyz Ridge. Legend: Habitat designations: quadrangle, afforested; circle, mosaic by afforestation; triangle top down, rich open habitats; triangle top up, impoverished open habitats; “house,” built-on; and semicircle, aquatic-peri-aquatic. Significant (superthreshold) linkages are designated by a solid line, the maximum upon a lack of significant ones are designated by a dashed line, and additional linkages are designated by a dotted line; mean similarity coefficients are given near linkages; numerals in signs designate numbers of taxa by classification; near the signs are names of habitats occupied by a taxon, three species leading by abundance, population density, individuals per 1 km<sup>2</sup>, and (after the slash) number of common species (whose abundance is 1 and more individuals per 1 km<sup>2</sup>). Trends are indicated by arrows; factors correlating with them are next to them.

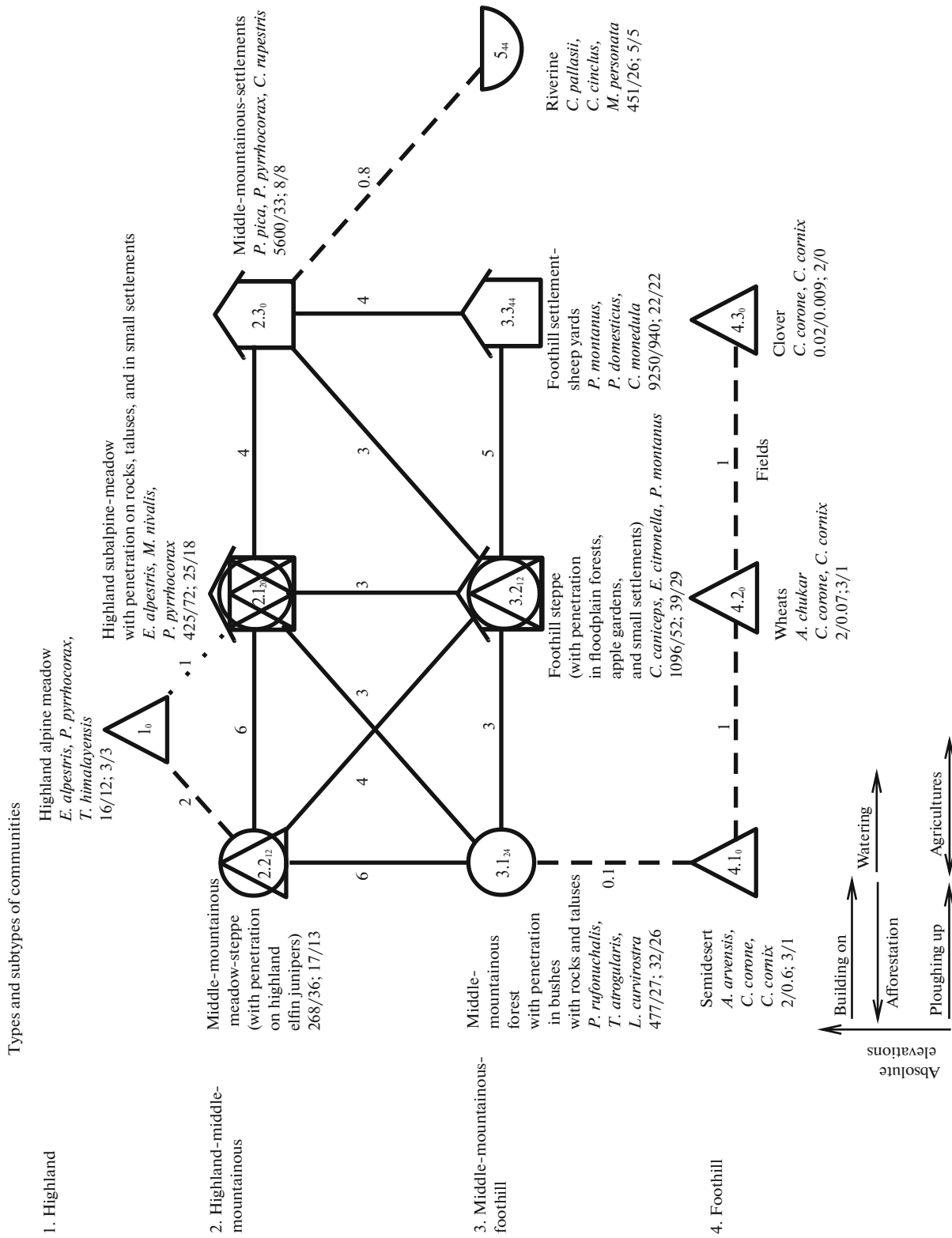


Fig. 2. Spatial–typological structure of early spring bird populations on the Kyrgyz Ridge. Legend is the same as for Fig. 1.

only in Tien Shan. Only the riverine type was described on the Kyrgyz Ridge due to the lack of explorations on lakes there, whereas on the Altai a singular lake–riverine type was identified. Therefore, a more detailed subdivision into types was obtained for the Kyrgyz Ridge than for the Altai. This is due not only to the presence of semidesert communities, but also to the higher heterogeneity of ornithocomplex characteristics.

The influence of the difference in moistening, along with the influence of absolute elevations, was demonstrated at the subtype level in Altai. This leads to the twoness of similar types of bird communities: arid and humid ones, by the influence of the depth and mosaicism of snow cover. The same differences were traced in mosaic and open habitats on both the Altai and on Tien Shan, but at the level of communities subtype. The synanthropic community type on the Altai is subdivided into two subtypes according to settlement sizes and the degree of permanence of humans staying there (the types of nomad camp and settlement). The influence of absolute elevations prevails on Tien Shan at the level of type via settlement size. This is not the case of Altai at the level of subtype of ornithocomplexes in the winter period. The stronger influence of absolute elevations on Tien Shan is more exact than on the Altai.

The cumulative informativeness of representations on the heterogeneity of winter communities on the Kyrgyz Ridge is higher than on the Altai (93 and 71%); as for the majority of general factors: watering 45 and 8, building on 17 and 8, ploughing up 5 and 1, except for afforestation: 5 and 41%. These differences are connected with the sample size, which is much larger for the Altai and, correspondingly, more heterogenic internally. The higher estimation of afforestation than on Tien Shan determines the presence of true forests with high density on the Altai, whereas on Tien Shan they are considerably rarefied. The systems of approximating environmental factors are significantly unequal due to differences in sample size, its heterogeneity, and the degree of generalization.

The composition of species, dominating by communities types, is significantly different. Only *C. livia*, *E. alpestris*, *C. pallasii*, *E. citronella*, *P. montanus*, *P. domesticus*, and *P. pica* may be considered common for them. The following species are typical for the Kyrgyz Ridge as leaders in winter: *T. himalayensis*, *A. chukar*, *V. vanellus*, *C. rupestris*, *S. decaocto*, *S. senegalensis*, *T. atrogularis*, *L. sophiae*, *P. rufonuchalis*, *C. caniceps*, *S. pusillus*, *M. nivalis*, *A. tristis*, *P. pyrrhacorax*, *C. frugilegus*, *C. corone*, and *C. cornix*. For the Altai these should be Mallard duck, Bluebill, Bullhead, Merganser, Tundra and White partridges, Long-tailed tit, Willow tit, Great tit, Nutcracker, Mountain and Godlevsky's bunting, Crossbill, Linnets, and Corbie. The differences in composition are connected with higher absolute elevations of the Kyrgyz Ridge and

Strength of linkage of environmental factors and heterogeneity of winter and early spring communities of birds on the northern macroslope of the Kyrgyz Ridge

Factor and regime	Estimated dispersion, period, %	
	winter	early spring
Watering	45	44
Food resources	20	5
Building on	17	18
Productivity	9	10
Number of bushes	8	7
Absolute elevations	6	4
Lack of forest	5	5
Presence of rocks and taluses	1	1
Ploughing up	1	1
<b>All factors</b>	<b>81</b>	<b>84</b>
Classification regimes	66	72
Structural	87	79
<b>All regimes</b>	<b>87</b>	<b>79</b>
<b>All factors and regimes</b>	<b>93</b>	<b>92</b>

broader afforestation of the Altai. Therefore, the participation of highland species as leaders is great in Tien Shan, whereas in the Altai this concerns forest species and, due to the high extent of exploration of lakes, also waterfowl.

On the average, for types of winter assemblage, the density and biomass is about 1.3 and 2.2 times higher on the Kyrgyz Ridge than that on the Altai, whereas species richness is 1.4 times lower, and the number of common species is almost similar. The number of faunistic types, prevailing by abundance in communities on both territories, is almost equal, 7 on the Altai and 8 on Tien Shan. A recalculation of the values per one communities type on Tien Shan gave the following result. Members of the European type of fauna and transpalearcts (0.7 and 0.5) prevail there; members of the Mongolian (0.4); Tibetan and Mediterranean (0.3 each); and Arctic, Chinese (0.2 each), and Siberian types (0.1) are less numerous. On the Altai, transpalearcts, members of the Siberian and European types, were found more often (0.7 each), whereas the Mongolian, Mediterranean, and Arctic types are rarer (0.3 and 0.2 each). Therefore, the Mongolian and Mediterranean types occur somewhat more frequently on the Kyrgyz Ridge, whereas the Siberian and European types, as well as transpalearcts, occur more often on the Altai. The occurrence of Arctic forms is equal. Members of the Chinese and the Tibetan faunistic types are among species prevalent only on the Kyrgyz Ridge. These differences are connected with higher afforestation, lower degree of its aridization, and generally lower absolute elevations of the Altai.



Intergroup similarity (recalculated pre one significant linkage reflected in the graph on the Altai) is thrice as low as on the Kyrgyz Ridge (3 and 10) and intergroup similarity is 1.5 times as low (14 and 23). These differences seem to be connected with the higher degree of aggregation accepted for the Altai.

### CONCLUSIONS

There is no clear coincidence in the borders of distributions of types and subtypes of winter and early spring bird assemblages and elevation belts. The trends revealed gradualism in the changes of bird communities by elevation levels: part of highland, middle–mountainous, middle–mountainous–foothill, and foothill habitats form singular vertical and horizontal rows on the graphs. Changes inside of them are related to differences in the extent of development of bushes, afforestation and ploughing up, and watering and composition of agricultural plants. The latter factor is connected with the presence of wheat seeds on snowless plots in cereal fields. Ornithocomplexes of a part of small settlements in early spring are similar to those in adjacent habitats; others, especially large ones, have specific communities. Maximum values of the total abundance and species richness are typical for middle–mountainous habitats. Aquatic and periaquatic communities of birds may have no common species with ornithocomplexes on natural and built-on territories, or have a weak connection with them via the communities of settlements.

In general, the heterogeneity of bird assemblages on the northern macroslope of the Kyrgyz Ridge in winter and early spring periods is connected with the variability in the provision of warmth and water, as well as with presence of built-on territories and monocultural agrocenoses. Changes of ornithocomplexes are more gradual in winter than in early spring.

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